Consumer Acceptance of Novel Breads Containing Vitamin D and Soy Given Three Different Nutrition Information Conditions

Ruth De Guire

Senior thesis completed in partial fulfillment of requirements to graduate with honors research distinction under the supervision of Drs. Neal Hooker and Yael Vodovotz

Abstract

Functional foods are an innovative area of food science that improve the health of consumers through the use of synergistic ingredients. A Vitamin D bread with soy was developed by scientists at the Ohio State University and is poised to reduce the deficiency of Vitamin D in the United States. A survey was conducted to see which identifying claims on four different breads (whole wheat, whole wheat with soy, whole wheat with 50% Vitamin D, and whole wheat with 100% Vitamin D) would make this product most appealing to consumers. The survey compared three levels of nutrition information: a front of pack (FOP) claim, a FOP claim with the traditional nutrition facts label, and a FOP claim with the proposed new nutrition facts label. It was hosted through Qualtrics, LLC and distributed to consumers in the state of Ohio. Across all three levels of information, a majority of respondents preferred traditional wheat bread, although a statistically significant shift of consumer preference towards whole wheat bread with 100% Vitamin D occurred between the FOP claim and the FOP claim with a nutrition label. Additionally, a majority of consumers, preferred to pay $2.00-2.99 per loaf, while a significant shift in willingness to pay occurred between the FOP claim and the FOP claim with a nutrition label. No change was noted in consumer preference with the new nutrition label. It was concluded that the financial success of the bread in the market place could not be guaranteed through the results of this survey alone, and that further study was necessary to understand consumer perception of claims, nutrition labels, and the impact of Vitamin D in the body.

Introduction

Vitamin D plays critical roles in the body and goes through a complex activation process. Vitamin D comes in two forms: Vitamin D_2 and Vitamin D_3. The first, Vitamin

D_2, is synthetically made and used to fortify foods, while the second, Vitamin D_3, is synthesized in the skin or consumed in animal products. Both are made active in the body through enzymatic hydroxylation reactions occurring in the liver and kidney. In the liver, Vitamin D is converted to 25OHD, which is then converted to the hormone calcitriol in the kidney. 25OHD is the major circulating form of Vitamin D in blood serum.

From there, Vitamin D is known to play essential roles in calcium absorption, maintenance of bone health, and activation of genes that are "involved in a wide range of classical and non-classical roles, such as the regulation of cell proliferation, cell differentiation, and apoptosis." (Ross, 2011) Vitamin D plays a unique role in controlling and defining cell growth and death cycles. Research seeking to further understand the role of Vitamin D in cell behavior suggests that Vitamin D has roles in cancer prevention and therapy and strengthening of the immune system (Ross, 2011). Vitamin D supports many functions in the body, from bone health, to immune system maintenance, and is readily available through diet or synthesis in the body.

Given the implications that Vitamin D has for promoting health, it is of concern that Vitamin D deficiency is widespread and increasing within the United States. Between the periods of 1988-94 and 2001-04, data collected by the Third National Health and Nutrition Examination Survey III (NHANES) displayed an increase in Vitamin D deficiency across age, gender, and ethnicity demographics (Ginde, 2009). While adequate Vitamin D has been linked to many health benefits, Vitamin D deficiency is evidenced by rickets in children, loss of bone density in older adults (Ross, 2011), and even an increase in cardiovascular disease, cancer, and reduced ability to fight infection (Ginde, 2009).

In the diet, eggs, fortified milk and butter, and fish or fish liver oil help reduce

Vitamin D deficiency. Exposure to sun is also a critical factor in Vitamin D production in the body. Populations at risk for Vitamin D deficiency include: those living in the north and experiencing seasonal deficiency, living with obese, or whose skin synthesis of Vitamin D is lower (Ross, 2011). Alleviation of Vitamin D deficiency may be achieved through fortification, supplementation, a change in diet, or greater exposure to sunlight.

However, conducting clinical trials to analyze and verify the positive functions of Vitamin D in the body are cumbersome, making recommendations for dietary consumption, fortification, or therapy tricky for at-risk groups. The primary limitation in studying Vitamin D is that the prohormone is fat-soluble. For this reason, mega-dosing with Vitamin D poses risks of toxicity as the vitamin builds up in adipose tissue. Preliminary studies examining Vitamin D in the body resulted in hypercalcemic conditions (Schwartz, 2009). Second, the recommended daily levels of Vitamin D necessary to prevent deficiency are on the nanomolar level in blood (Hoolis, 2007), while the activated form of Vitamin D circulates at the picomolar level (Hoolis, 2007). This makes the Vitamin difficult to measure in blood serum levels and DRI nearly impossible to suggest given the geographic diversity of the nation (Kupferschmidt, 2012). Lastly, and most importantly, clinical assays of serum Vitamin D blood levels are difficult and unreliable (Hoolis, 2007). As previously mentioned, Vitamin D is extremely hydrophobic and circulates in two forms in the body (Hoolis, 2007). In the blood, Vitamin D often forms complexes with other hydrophobic functional groups, making it hard to isolate (Hoolis, 2007). Many existing assays are proprietary and only ensure a degree of accuracy, while other destructive methods, such as HPLC and LC-MS, are both too slow for clinical studies (Hoolis, 2007). The analytical limitations in quantifying and studying the impact of

Vitamin D prevent the validation of clinical trials that would support DRI levels for populations at risk for deficiency.

Furthermore, there is debate regarding the true, and proved, importance of Vitamin D in biological systems. Critics of the vitamin and its study suggest that, similar to previous "cure-alls" like beta-carotene and Vitamin A, there is building evidence that Vitamin D does not have as far-reaching an impact as previously believed (Kupferschmidt, 2012). It is noted that too many serious limitations, such as isolating the impact of Vitamin D in the body to the average cost of running Vitamin D clinical trials, prevent the production of verifiable results (Kupferschmidt, 2012). Vitamin D is also one of the only vitamins produced in the body, so only 10% comes from the diet (Kupferschmidt, 2012). With limitations in study and limited impact of dietary intake of Vitamin D, any further research in Vitamin D may be futile or yield insignificant results.

Nonetheless, evidence does exist that Vitamin D supports critical health cell behavior and that there is a notable deficiency of it in the diet. For example, a study done in Mongolia and Japan noted that Vitamin D supplements reduced incidences of cold and flu (Kupferschmidt, 2012). Further, it has been observed in lab samples that prostate cells process Vitamin D to improve differentiation and prevent proliferation. It was noted by author Schwartz, "There is presently no standard care for men with recurrent disease. [Men with risk of recurring cancer] comprise an attractive group for Vitamin D-based interventions because their disease burden is relatively small and their cancers may be better differentiated than in advanced disease" (Schwartz, 2008). Men at risk for prostate cancer are ideal candidates to study the impact of Vitamin D therapies on the prevention of future disease. Further, studies in sun-poor regions, such as Denmark, do suggest that further fortification of foods would support the alleviation of Vitamin D deficiency (Madsen, 2013). Vitamin D deficiencies are also typically found in overweight and obese children (Turer, 2012), populations who are also at risk for many other diseases that Vitamin D is involved in preventing. Although measuring Vitamin D in the body poses unique obstacles, it still serves known and critical functions that cannot be disregarded in overall consumer health.

All together, Vitamin D deficiency is complex. It is understood and proven that Vitamin D deficiency impacts many areas of health, yet proposals for treatment are hard to standardize and verify. In this space of necessity and complexity, functional foods provide a happy medium between semi-regular to regular dosage of the vitamin over an extended period of time, guaranteeing perpetual yet minimal dosage. Some foods, such as milk and butter are already fortified with Vitamin D (Ross, 2011). However, these products do not suite consumers with low food budgets or dairy intolerances. Foods like bread that are consumed daily and at affordable prices balance this nuance of affordability and nutritional content. If bread were fortified with Vitamin D, a consumer would, after consumption of the loaf over time, have consumed some Vitamin D without the negative impact of super-dosing.

Scientists in Dr. Yael Vodovotz's lab at the Ohio State University Department of Food Science and Technology formulated such a bread. The bread contains proprietary yeast that produces Vitamin D with fermentation (Vodovotz, 2015). Thus, Vitamin D levels are completely independent of any sensory or product cost factors in the bread. The synergistic ingredient in the bread is soy. Soy contains compounds known as isoflavones. Genistein, a type of isoflavone, is directly linked to the death or inhibited growth rate of cancerous prostate cells (Roa, 2002). Although the mechanism is unknown, a synergy was observed in the reduction of proliferation of human epithelial prostate cells when cell lines were treated with genistein and Vitamin D (Roa, 2002). The synergistic use of these two ingredients makes this bread a "functional food."

Functional foods, as defined by the Academy of Nutrition and Dietetics, increase or improve nutritional impact through the use synergistic or fortifying ingredients (Crow, 2013). Functional foods are a relatively new area of food and food marketing. With traditional food products, studies of consumer perception of food claims suggest that claims are often perceived as credible health information and often link consumer thought processes to "diet-disease" relationships (Roa, 1999). This study is important because labeling of functional foods is not yet regulated to prevent misleading consumers to perceive medical functions of the food. For example, consumers may believe eating bread with Vitamin D and soy will prevent all risk of prostate cancer if the claim is misleading. The results of this study contribute to the on-going understanding of how consumers perceive health information, especially as presented on innovative foods designed for health.

Contributing to an ever-evolving discussion of consumer use and interaction with types of nutrition information is the FDA proposed changes to the nutritional label. The new label adds Vitamin D and potassium to the micronutrient section but remove Vitamin A and C. The new format also draws consumer attention to calorie count and percent daily value of each nutrient. According to the FDA, the changes are meant to change consumer behavior and increase the purchase of "healthier" products. In comparing consumer preference across three nutrition information conditions, conclusions will be made about consumer preference for types of food with different health implications as the information level changes. (FDA, 2014.

Materials and Methods

The survey tested the impact of three nutrition information conditions on consumer preference for breads with whole wheat, whole wheat with soy, and whole wheat with soy and 50% Vitamin D or 100% Vitamin D (Figure 1.a). Additional questions measured consumer attitudes about shopping, average consumption of bread, and demographics. The inclusion of four free-response sections provided qualitative and anecdotal insight into consumer attitudes towards bread, nutrition information, and perceived health benefits of the bread.

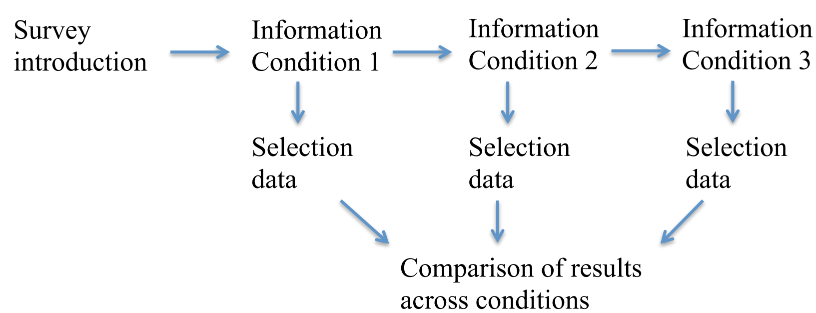
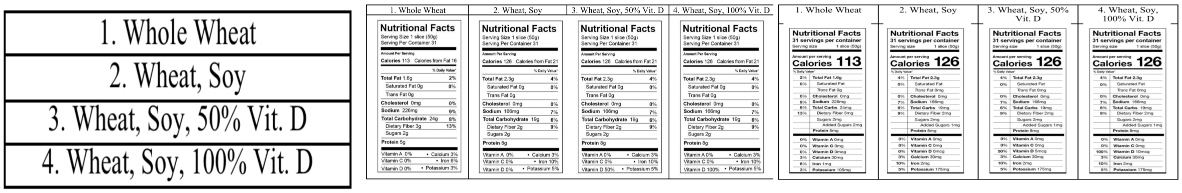


Figure 1.a Survey Structure and Test Conditions

The information conditions selected included a front of pack claim (condition 1), a claim with a nutrition label (condition 2), and a claim with an updated nutrition label with changes as proposed by the FDA (condition 3), as shown in Figure 1.b. In each condition, consumers were prompted to select the bread that appealed to them the most. Prior to seeing the third condition, consumers were alerted to the proposed changes to the nutrition label by the FDA and how these changes were proposed to improve consumer readability of the label. Pictures of bread were not included so as to prevent consumer bias towards favored brands.



1. 2. 3.

Figure 1.b Examples of information conditions 1, 2, and 3

Respondents were recruited through an e-mail list-serv maintained by the Ohio State University Food Science and Technology Department. The e-mail body introduced the survey, provided contact information for further questions, and a link to the survey hosted by Qualtrics, LLC. The survey introduced the study in greater depth, providing the respondent with the option to opt-out and to agree to participation. A donation towards a scholarship for a student at Ohio State University was given in exchange for the respondent's time. Only completed surveys contributed to the fund. The survey consisted of twenty questions and took participants less than fifteen minutes to complete. Type of questions included multiple choice, ranking, and free response.

Limitations of this study include the variance of nutritional information between whole wheat bread and breads with soy. Differences in protein, fiber, and other nutrients were not controlled for so as to keep the nutrition label for soy breads as close to the ideal found in the lab and in sensory panels.

Results & Discussion

A total of 583 responses were collected by the close of the survey. 467 surveys were completed in their entirety. Table 1.a below shows the percent of respondents that selected each bread type at each given condition. Each bread type was given a different number value (whole wheat = 1, whole wheat bread with soy, 100% Vitamin D = 4) that was used in statistical analysis. A two tailed t-test with $\alpha=0.05$, yielded $p<0.0001$ between conditions 1 and 2, suggesting a significant difference in consumer preference between the two. However, a similar test between condition 2 and 3 yielded p = 0.9054, suggesting that there was no statistically significant difference between condition 2 and 3. The shift between condition 1 and 2 indicates a consumer increase in willingness to purchase bread with Vitamin D with nutritional information that supported the FOP claim. However, a limit of shifting between the second and third information type suggests that consumers were not swayed by a new layout of the nutrition label. Differences between condition 1 and 3 were not measured, as respondents did not see condition 3 directly after condition 1. Across all three information conditions, a majority of consumers still preferred whole wheat bread (>50%).

Table 1.a Percent of respondents that selected each bread type across information conditions

	Condition 1	Condition 2	Condition 3
Whole wheat bread	84%	62%	64%
Whole wheat bread with soy	1%	8%	6%
Whole wheat bread with soy, 50% Vit D	5%	4%	4%
Whole wheat bread with soy, 100% Vit D	10%	26%	27%
Respondents	516	496	481

With each loaf selection, consumers were asked to select what price they would expect to pay for their bread of choice. Table 1.b below displays the amount that respondents were most likely to pay for their bread of choice. From condition 1 to condition 2, there was a 7% shift away from the $2.00-$2.99 and a 6% shift towards the $3.00-$3.99. A two-tailed t-test between condition 1 and condition 2 with $\alpha=0.05$ yielded p=0.00053, suggesting a statistically significant change in consumer price expectations for bread. There was no statistically significant shift between condition 2 and 3. Including nutritional information to substantiate front-of-pack claims increases a consumers' willingness to pay, and that consumers will pay more for a product that is perceived to hold more benefit after closer examination of a nutrition label, no matter its format. However, the majority of consumers prefer to stay within the $2.00-$2.99, as displayed by >60% respondents in each information condition. This indicates that a majority of consumers are not willing to pay a premium for functional breads.

Table 1.b Expected price of respondents for bread selected

	Condition 1	Condition 2	Condition 3
$2.00-$2.99	69%	62%	62%
$3.00-$3.99	27%	33%	33%
$4.00-$4.99	3%	5%	5%
Respondents	516	498	483

Consumer's willingness to purchase bread of choice did not vary significantly between conditions 1, 2, and 3. A t-test with α=0.05 yielded p=0.3494, indicating no significant change between condition 1 and 2. The most likely option of respondents was the "likely to purchase" option. Conditions 1, 2, and 3 did not sway consumer certainty about preferred purchase or a hold significant value in consumer willingness to purchase. An area for future study could quantify the impact of FOP and nutrition labeling on willingness to purchase.

Table 1.c Consumer willingness to purchase bread of choice

	Condition 1	Condition 2	Condition 3
Unlikely	17%	17%	16%
Undecided	15%	19%	18%
Likely	67%	64%	65%
Respondents	517	497	483

Table 1.d displays the demographics of respondents surveyed. The demographics of most interest were the average age and female bias of the respondent pool. These two are significant because the bread was formulated for a middle-aged consumer. Secondly, it was hypothesized that a middle-aged, female consumer would prefer soy breads given the connection between soy and the relief of menopausal symptoms (Han, 2002). In comparison to the 2013 Ohio census, the population surveyed was not representative of the greater Ohio population, which as a whole is younger, less educated, and evenly male and female in comparison to the respondent pool. However, due to the recruiting tool used, it is known that respondents lived in Ohio, and thus represent similar types of consumers found in the state if not the greater population.

Table 1.d Average respondent demographics

	Average of respondents	Ohio 2013 Census
Frequency of bread purchase	Every other week	NA
Age	40-59 yrs	56% between 19-64
Gender	77% Female	51.1% Female
Level of education	72% College or higher	25.2%
Household income	$60-70,0000	$48,308

From this data, Vitamin D and soy bread may not be as financially successful in the marketplace as expected using F.O.P and nutrition labeling. Providing a nutrition label between condition 1 and 2 shifted a statistically significant number of consumers towards soy bread with Vitamin D, but a majority of consumers still preferred whole wheat bread. The bread may be optimized for use in niche markets, such as hospitals treating prostate cancer patients, in dietary therapy for people at risk for Vitamin D deficiency, or in public health campaigns during winter months in groceries.

Conclusion

Vitamin D deficiency is problematic in the United States, increasing the likelihood of many chronic diseases, such as cancer or bone thinning. Deficiency of Vitamin D is also hard to treat as it is hard to measure in the blood, has not been definitively linked with the prevention of any one disease, and can be toxic with mega-dosing. However, the development of bread with Vitamin D can solve this problem neatly. Bread is consumed regularly, ensuring steady dosage across demographics. The survey conducted did not support the hypothesis that a majority of consumers would prefer bread with 100% Vitamin D, but providing a nutrition label did shift consumer preference significantly. These results contribute to current studies of functional foods in two ways. First, this study found that consumer interaction with the new nutrition label is not yet optimized or well understood. With the intent of being user friendly and of inducing “healthier” purchases, this label failed to change consumer preference. Further changes in the label must be made if shifting of consumer purchase of foods rich micronutrients is desired. Second, the functional bread was more accepted when consumers were given a nutrition label. However, with little quantification of what sways consumer preference most, a FOP claim or nutrition label, and how that preference shift occurs, it is suggested that an alternative way to introduce this bread to consumers is through specific application, such as in diet therapies, food pantries, or in operations that include medical treatment.

Works Cited

Crow K, Francis C. 2013. Position of the Academy of Nutrition and Dietetics: Functional Foods. Jrnl of the Acad of Nut. and Dietetics 113: 1096-1103.

Farhan H, Wähälä K, Adlercreutz H, Cross H. 2002. Isoflavonoids inhibit catabolism of Vitamin D in prostate cancer cells. Journal of Chormatography B 777: 261-268.

[FDA] Food and Drug Administration. 2014. Proposed Changes to the Nutrition Facts Label. (Updated: 8/1/14, Accessed: 4/13/15)

Ginde A, Liu M, Camargo C. 2009. Demographic Differences and Trends of Vitamin D Insufficiency in the US Population, 1988-2004. Arch Intern Med. 6: 626-632.

Han K, Soares J, Haidar M, de Lima G, Baracat E. 2002. Benefits of Soy and Isoflavone Therapeutic Regimen on Menopausal Symptoms. Obstetrics & Gynecology 99: 389-394.

Hoolis, B. 2007. Assessment of Circulating 25(OH)D and 1,25(OH)D: Emergence as Clinically Important Diagnostic Tools. Nutrition Reviews 65: S87-S90

Roa B, Levy A, Derby B. 1999. The impact of Health Claims on Consumer Search and Product Evaluation Outcomes: Results from FDA Experimental Data.
Journal of Public Policy & Marketing 18: 89-105

Ross A, Taylor C, Yaktine A, Del Valle H. 2011. *Dietary Reference Intakes*: *Calcium and Vitamin D.* Washington, DC: The National Academies Press. Ch. 3

Kupferschmidt K. 2012. Uncertain Verdict as Vitamin D Goes On Trial. Science 337:1476-1478.

Madsen K, Rasmussen L, Andersen R, Molgaard C, Jakobsen J, Bjerrum P, Andersen E, Mejborn H, Tetens I. 2013. Randomized controlled trial of the effects of Vitamin D-fortified milk and bread on serum 25-hydroxyVitamin D concentrations in families in Denmark during winter: the Vitamin D study. Am J Clin Nutri 98: 374-82

United States Census Bureau. Ohio Quick Facts. 4/13/15. Washington DC: United States Department of Commerce. Available at: http://quickfacts.census.gov/qfd/states/39000.html. Accessed: 4/12/15

Roa A, Woodruff R, Wade W, Kute T, Cramer S. 2002. Genistein and Vitamin D synergistically inhibit human prostate epithelial cell growth. The Journal of Nutrition 132: 3191-3194.

Schwartz G. 2008. Vitamin D and Intervention Trials in Prostate Cancer: from Theory to Therapy. AEP 19: 97-102.

Turer C, Lin H, Flores G. 2012. Prevalence of Vitamin D Deficiency Among Overweight and Obese US Children. Pediatrics 131: 152-162.

Vodovotz Y, Ahn-Jarvis J. 2015. The Ohio State University. 2015 Fyffe Road, Columbus, OH 43210.